

A Diode-Laser Holographic Imaging System Applied to the Study of Fluids in Microgravity

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Purpose

The primary purpose of this research is the development of a compact, state-of-the-art, modular holographic imaging system, based on laser-diode technology that incorporates micro-optics in order to record full 3D images of a test cell. The apparatus is designed to be compatible with a variety of test cell modules. The device could find applications in ground-based laboratories, as well as reduced gravity environments, such as the Space Shuttle, the KC-135 aircraft, and sounding rockets.

Background

Holography is an important research method because it records an image of the entire volume of a test cell at a given instant in time. When a hologram is constructed it records the wavefront coming from the test cell. Then when the hologram is reconstructed the same wavefront is reproduced. The reconstructed wavefront can be analyzed by the same optical techniques that could have been used on the original test cell. This capability is important in many areas of research, such as solution crystal growth, fluid physics, and particle phenomena. For example, quantitative studies of the growth of transparent dispersions require diameter measurements from numerous microscopic droplets at a given instant of time in order to produce statistically significant results. Typically, the droplets will be undergoing changes in position or size as the experiment progresses.

Accurate measurement of the entire population of droplets is impossible by normal techniques. However, by recording a hologram of the experiment the entire test cell volume is stored. The entire test cell from the reconstructed hologram can be investigated by microscopy to measure all the droplets.

Accomplishments

A miniaturized holographic system was constructed based on current optics and laser diode technology. An optics breadboard table that fits inside a Shuttle locker was used to construct the holographic system using miniaturized optical components. Most of the optical components were off-the-shelf items. However, a customized 70-mm movie camera was used as a film holder and film transport system in the holographic system. After the holographic system was built, it was tested in a ground-based laboratory and flown twice on the KC-135. A variety of fluid experiments were performed in the system to demonstrate its capabilities.

A microgravity fluids module was designed and tested. The fluid system tests included various modes of fluids processing, such as dispersion generation, fluid delivery, and heating. The fluids module was flown in the holographic system on the KC-135 to help define its capabilities.

Upon completion of the analysis of the last KC-135 flight experiments, a paper will be written

detailing the optics system and its capabilities. This paper will be submitted to the *Journal of Applied Optics* for publication. Another paper concerning the KC-135 fluid experiments is planned for the *Journal of Microgravity*.

The results of this work are directly applicable to the RTOP “To Further Investigate the Influence of Microgravity on Transport Mechanisms in a Virtual Space Flight Chamber.” One of the objectives of the RTOP is to design a new space flight experiment that would be superior to any existing flight hardware in its capabilities to both monitor critical crystal growth parameters and directly measure microgravity effects such as residual gravity and g-jitter.

Planned Future Work

The 2-year CDDF is at its end. The KC-135 flight system is available to perform demonstration experiments, both on the ground and on the KC-135. Modifications to the vibration isolation for the KC-135 might be made prior to future flights.

Funding Summary (\$k)

The complete funding for the 2-year life of the CDDF was 88k.

Status of Investigation

The investigation was a 2-year CDDF investigation and is at the end of its time period. The knowledge gained from this study will now be applied to a flight experiment definition study, “Investigation of the Influence of Microgravity on Transport Mechanisms in a Virtual Space Flight Chamber.” This study will define a space flight experiment using holography to record the data.

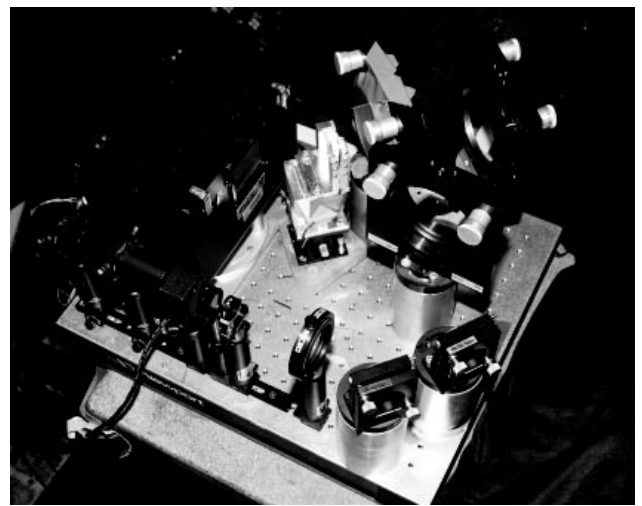


FIGURE 26.—Sideband flight system.

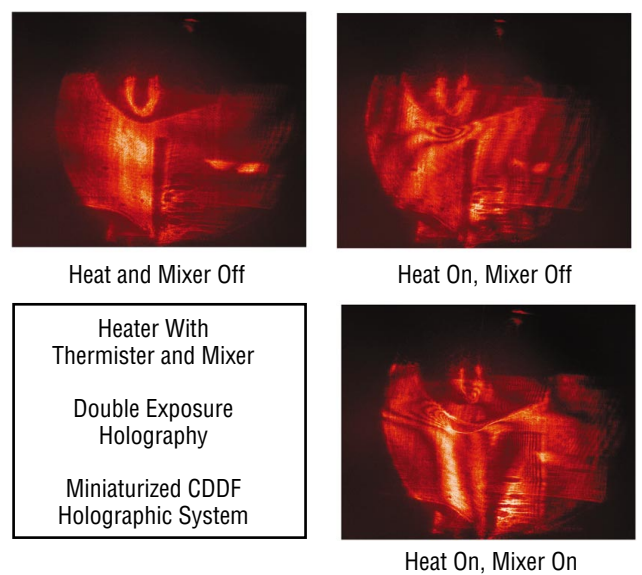
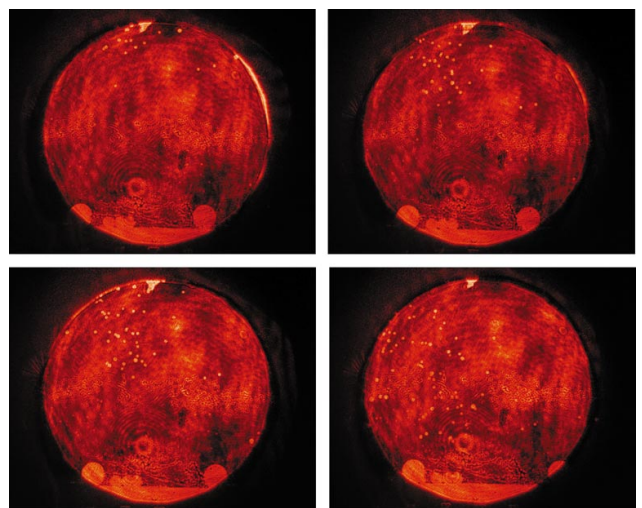


FIGURE 27.—Heater and mixer (KC-135).



Particle Motion: g-jitter

FIGURE 28.—Particle motion (KC-135).